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THE REDUCTION OF THE RARER METALS FROM THEIR OXIDES.

PAPER BY PROFESSOR W. C. ROBERTS-AUSTEN, C.B., F.R.S.

PROFESSOR W. C. ROBERTS-AUSTEN, C.B., F.R.S., read a paper on the above subject on Wednesday last, before the Society of Arts.

The Author said : My communication can hardly be dignified by the name of a paper, but I thought that as the question of the reduction of the rarer metals from their oxides was one which was assuming very great importance, it might interest the members of the Society if I briefly showed them the methods by which this reduction can be effected.

When a metal is separated from a state of chemical combination it is said to be "reduced," and the process of separation is termed "reduction." For centuries the main agent employed for this purpose was either carbon or the gas carbonic oxide which is produced by its partial oxidation of carbon. Carbon has been used for the reduction of metallic oxides from times of which we have no written history, but the early metallurgists also availed themselves of a complex series of reactions which take place when metallic oxides are heated with metallic sulphides, without, however, understanding the nature of the mutual action of these substances on each other. Copper, for instance, must have been so separated from its ores without the direct action of carbon as a reducing agent from very early times, but carbon is still the agent by which reduction is effected in that vast metallurgical appliance, the blast-furnace, used for smelting iron.

There are, however, many metallic oxides which will not part with their oxygen to either carbon or carbonic oxide. Alumina is an instance ; its reduction by carbon can only be effected at a very high temperature, aided by the tearing effect of the electric current. At the very high temperatures at which carbon may be vapourised, some 3600° C., the reducing action of carbon vapour is probably energetic.

The history of the gradual introduction of other reducing agents is very interesting, but it will only be incidentally touched upon in order to make the nature of modern operations clearer than it otherwise would be.

At the beginning of the century, it became evident that metals might be used at high temperatures as reducing agents. Thus, in 1809, Davy, Gay-Lussac, and Thénard obtained the metals of the alkalis, and it was soon found that metallic potassium and sodium was a powerful weapon for separating oxygen from other metals. It often happened that the chloride was operated upon with the alkali metal ; thus Berzelius obtained the metal yttrium, in the form of a grey powder, by heating its chloride with potassium.

Thus, to take an important case, Wöhler obtained metallic aluminium in 1822 as a grey powder by the action of potassium on aluminium chloride ; and he afterwards, in 1854, obtained it as a white compact metal, unoxidisable in air, and acted on water difficulty by acids.

Mosander (1839) obtained metallic lanthanum and cerium by heating their chlorides with potassium and sodium respectively. Marignac was the first to prepare metallic didymium by heating its chloride with potassium. Or, to take another case : Wöhler obtained crystalline chromium by igniting a mixture of anhydrous chromic chloride with finely-divided zinc and sodium and potassium at the boiling point of zinc. Fremy also prepared crystalline chromium by the action of the vapour of sodium on anhydrous chromic chloride in a stream of hydrogen. Uranium is another metal which was separated by the aid of sodium ; for, in 1841, Peligot ignited oxide of uranium UO_3 , with charcoal in a stream of chlorine. He thus obtained volatile uranium tetrachloride, UCl_4 , which, when heated with oxygen, gave metallic uranium as a grey metal.

In 1863, indium was discovered in the Freiberg zinc blends by Reich and Richter. It is best prepared by fusing the oxide with sodium as Winkler describes (*Journ. Pract. Chem.*, cii. 273).

I hope at an early day to find time to deal fully with the history of the use of certain metals for the reduction of the oxides of the rarer metals ; at present I would only refer to a very interesting paper by H. F. Keller, who points out that Beketoff used aluminium for the reduction of potassium hydroxide. There can be no question that the cheapening of magnesium and aluminium will have a great influence in metallurgical operations conducted with a view to the extraction of the rarer metals from their oxides, and, as Keller states, Clemens Winkler, of Freiberg, has made a systematic investigation of the reducing action of magnesium upon oxides ; while Seubert and Schmidt have conducted a similar investigation as to its action on chlorides.

Among the very early work in this direction on a practical scale must be mentioned that of Green and Wahl, whose patent is dated February 11, 1893 (No. 82). They obtained manganese and manganese alloys free from carbon, and this freedom from carbon is a point of the utmost importance. Manganese can be reduced from its oxides by the action of carbon and carbonic oxide, but the manganese so obtained always contains carbon, and when it becomes a question of the addition of manganese to a bath of molten steel, the simultaneous introduction of carbon may be a matter of great moment, as a few hundredths of one per cent. of carbon, in certain varieties of steel, is not to be lightly considered.

At a soirée of the Royal Society last year Mr. Vautin exhibited some very interesting specimens of the rarer metals, which, aided by Mr. Pickard, he had himself extracted mainly

from their oxides by the use of finely-divided aluminium—granulated aluminium, that is—which is obtained by vigorously stirring molten aluminium while it is passing from the fluid to the solid state. Many of the specimens obtained by Mr. Vautin are exhibited to-night. I have obtained certain other specimens, and have employed them in the course of a recently conducted research.

There are certain experiments connected with the reduction of oxides by aluminium which it may interest you to see. I will therefore describe them.

In this little furnace there is a small crucible, which contains oxide of chromium and aluminium. The temperature is being raised to a point which we have very carefully measured ; it is 1015° C. I might have arranged the experiment with a thermo junction plunged into the mixed mass of aluminium and oxide of chromium, and you would have seen that as soon as a temperature of 1015° is reached the aluminium reacts on the metallic chromium. You will see a slight evolution of heat, light, and smoke ; and left behind in the crucible will be a little button of chromium. The reaction takes place comparatively quietly, but I think you will be able to see it. It requires a certain initial temperature for the aluminium to act on the oxide of chromium, and in this case that temperature is 1015°. [The reaction took place quietly, but a shower of sparks was projected from the crucible.] We will break open the crucible presently, and there will be a little button of chromium left behind.

Now I will perform another experiment. I will take a little oxide of lead and metallic aluminium. Oxide of lead is very easily reduced ; oxide of chromium is very difficult to reduce, as you have already seen. Oxide of lead in two minutes will be reduced with something approaching explosion. It is not at all an easy experiment to arrange, in fact, it is very difficult ; if you make the charge too large you will blow the furnace to atoms, as we have done on many occasions. The difficulty is to produce a sufficient effect to satisfy you, perfectly free from any risk of danger [explosion took place like a rifle shot], and I am glad to say we have succeeded. The thermal conditions are all in our favour in this experiment ; the aluminium reacts with great readiness on oxide of lead, and presents having so easy a task to perform, and expresses itself in a loud manner.

If you take, instead of oxide of lead, litharge which has been melted and ground up, the reaction is smaller and explodes very much like a squib. When it is a case of a very difficult reducible oxide the reaction takes place in a much more gentle manner. You may have variations from violent explosions, which will shiver the furnace, to the slow, gradual action of some of the more difficult oxidisable materials.

I now come to another totally different method of obtaining the rarer metals from their oxides, and the development of this method we owe to the distinguished French chemist, M. Moisson. He has pointed out that metallurgists have recently employed currents of high tension for the electrolysis of metallic compounds. The new methods of preparing aluminium and magnesium are cases in point. The heat furnished by the electric arc can, moreover, be used in the reduction by carbon of certain oxides which have hitherto been considered to be irreducible. The great merit of Moisson's work consists in the fact that he has separated the heat action of the arc from the electrolytic action. He makes the heat reverberate on to the substance to be reduced, and, by the use of currents of 400 ampères and 60 volts, he has given us a remarkable series of metals, usually, however, associated with carbon.

Mr. B. KITTO said he had listened with very great pleasure to the paper, but he had hoped to hear more about the reduction of the rarer metals by means of aluminium, as introduced to the world by the labours of Mr. Vautin. He had himself been more particularly interested in uranium, and had spent a good deal of time in endeavouring to obtain that metal from its compounds. Professor Roberts-Austen had told them that the metal had been obtained by acting on the chloride with metallic sodium ; but, he must say that, having tried that method, he had failed. Knowing that Mr. Vautin had been very successful in reducing such oxides of the metal chromium, and others equally refractory, he mentioned his work to him, and asked him to be good enough to try the oxide of uranium. He prepared some of the oxide in a particular form, which, he understood, was used by Moisson, and took it to Mr. Vautin's laboratory, and Mr. Pickard—by whom, he believed, a great deal of the work had been done—treated it with specially-prepared

You almost always get carbides of the metals by this method. By placing oxide of uranium U_2O_5 in the electrical furnace, and passing a current of 450 ampères and 60 volts, Moisson obtained uranium containing 5 to 13 per cent. of carbon. From oxide of manganese, using 300 ampères and 60 volts, he obtained carbides of manganese containing 6 to 14 per cent. of carbon. From chromium oxide Cr_2O_3 , using 350 ampères or 50 volts, or even less, he obtained carbides of chromium containing 8.6 to 12.85 per cent. of carbon. Zircon when treated in the electrical furnace, using 360 ampères and 60 volts, yields either carbon-free zirconium or a carbide containing 4 to 5 per cent. of carbon according to whether you take a small or a large supply of zircon to reduce. Again tungsten, from tungsten acid, using 350 ampères and 70 volts, you get either carbon, free tungsten, or carbides, with it may be as much as 18 per cent. of carbon ; but you can easily get tungsten carbon free by melting the carbide with excess of oxide. Molybdenum is obtained by calcining molybdate of ammonia, using 350 ampères and 70 volts ; you get a very hard carbide, containing about 9.88 per cent. of carbon. Oxide of vanadium is obtained by calcining a salt of vanadium. You get carbides rich in carbon, containing 17 to 25 per cent. of carbon. In that way he has given us practically all the rare metals.

I cannot do better than project on the screen the interior of the furnace, not, however, using it for the reduction of metallic oxides, because if I did that you would practically see nothing

unless you waited for some 20 minutes. I prefer to melt up some chromium, and we will project the image of the fluid mass on the screen. Chromium is a very difficult thing to melt. Over a hole in the cover of the furnace is a mirror, and a lens so arranged that the light coming up will be reflected on the mirror and thrown on the screen. You now see the poles and the base of the furnace. You are looking down into the furnace as if you were standing over it. The chromium is hanging a little to the side, but it will gradually melt down. The arc is not passing straight from pole to pole, but is deflected down by a magnet.

You can measure the temperature in this way, by detaching a piece of the carbon pole, and dropping it quickly in water. You thus find out how much heat is transferred to the water, and in that way you can estimate the temperature. Subsequently you can determine the temperature which has been attained in the furnace itself. Speaking from previous results, I know the temperature in the furnace before you now cannot be less than 2500° C., and probably it is a little higher.

I will now melt some wrought-iron nails, which you will see will run down very soon.

[The experiment was then performed.]

I was right in insisting upon the fact that I have not dignified this brief communication by the title of a "paper," but the experiments are so very beautiful that I could not refrain from showing them to the members. Of the uses of the metal now that we have them it is impossible to say very much, but I need only remind you of the extraordinary importance, in armour plates and projectiles of the introduction of the metal chromium or nickel, in small quantities, to show that these must have an important future. With apologies for the brevity of this communication, that is my case.

THE DISCUSSION.

The CHAIRMAN said he was sure that he should only be interpreting the sentiments of those present in proposing a hearty vote of thanks to Professor Roberts-Austen for his very charming paper and for the beautiful experiments which they had the privilege of seeing. In a country like this, the basis of whose prosperity might almost be said to rest on metallurgy and the application of metals the matters that had been brought before them that evening were evidently of primary importance. In saying that we rested on a metallic basis, he did not wish to be understood as in any way to be alluding to that thorny subject of bimetallism, about which he supposed they might argue for three days and three nights and never come to an end of the subject, but he alluded to those applications of metals to commerce and the manufactures of this country, upon which it was no hyperbole to say that the prosperity of this country depended. The matters brought before them that evening were interesting not merely to those who made a study of metallurgy, but to the whole of the country, in fact the whole of the world, especially their own country. Most persons already dimly saw the great future which was before aluminium, and large works were being started to produce it in commercial quantities. Everyone would watch this experiment with great interest. One could not help seeing that we were only on the threshold of discovering other metals of perhaps more utility than aluminium, the future of which no one could possibly prognosticate. In conclusion, he begged to propose a cordial vote of thanks to Professor Roberts-Austen for his interesting paper.

Mr. C. T. J. VAUTIN said he was glad of the opportunity of referring to the reduction of oxides by means of heat generated by electric energy, and could not do so without referring to Siemens. Siemens, as was stated in every text-book, had described an electric furnace in which one pole was at the bottom and the other at the top, and with that furnace he witnessed in Melbourne, some ten years ago, the production of nearly every one of the carbides, or combinations of metals in carbon, which the illustrious French chemist Moisson had since produced. It was knowing what had been done in a quiet way by a gentleman, who, he regretted to say, never published anything at all, Mr. Newbury, with whom he was fortunate in being associated, and after M. Moisson started his work he determined himself, if possible, to try and produce some of the metals free from carbon. These results were obtained to a great extent in consequence of being able to obtain aluminium in a finely-divided form, and this was only done after several mechanical means had been tried and failed. It was through Mr. Pickard's energy and research that they were able to obtain aluminium in a form most suited for reduction. So far as chromium was concerned, very large quantities were now being daily produced in Germany, as much as 4 or 5 dwts. at one casting, containing as little as 4 per cent. of aluminium and not 1 per cent. of silicon. It was hoped that even that small quantity of silicon would be reduced by getting purer magnesia to work with. They were now producing alloys of calcium and iron containing 26 per cent. of calcium, and with these alloys experiments were being made for the purpose of desulphurising iron ; and from results which had been communicated to him, though not from his own experiments, he believed there might be some commercial application for such an alloy. Referring once more to the splendid work of M. Moisson, he had the pleasure in Paris of looking at a number of his products, and the only thing which struck him there as being against the electrolytic method was its great cost as compared with the method of reduction by means of aluminium, which could now be obtained at as low a price as three marks per kilo—upwards of 99 per cent. as it was produced at the Nordhausen works. Aluminium reduced with the greatest ease sodic oxide, calcic oxide, and barium oxide. On the other hand, by no method he had heard of, could they induce sodium to reduce alumina, and he thought it was doubtful whether potassium reduced alumina *per se*. On the other hand, the oxides of potassium and sodium could be re-

duced with the greatest ease by means of aluminium. There were some curious facts in connection with these reductions which were hardly fitted for that evening's discussion, but he hoped to have an opportunity some other time of bringing them forward.

Mr. H. C. JENKINS said that some year or two ago Dr. Ball and himself, looking at the problem of the desulphurisation of iron, came to the conclusion that the metal calcium was the important agent in desulphurisation by means of calcium chloride, and it occurred to them, Why not put calcium in as a metal or as a carbide? By the kindness of Professor Roberts-Austen one or two experiments were tried, but it was soon found that the cost would, under existing conditions, be too great, and the matter was dropped; but there was no doubt the calcium did take out the sulphur. He was glad to hear that Mr. Vautin had managed to obtain in a very easy way an alloy with the iron itself, which might lead to some great development in the future.

aluminium, and succeeded in getting a button of alloy the size of a pea. Upon analysing it, he found it yielded 62·63% of uranium, about 35 per cent. of aluminium, and the remainder he believed, was silicon. He was very anxious to hear whether Professor Roberts-Austen had succeeded in getting that particular metal in a pure form, and also whether he had tried any of the other oxides—for instance, U₃O₈—and, if so, what success he had achieved by means of the granulated aluminium, as suggested by Mr. Vautin and Mr. Pickard.

Mr. ROGER WALLACE said he should like to say a few words in praise of the work that Professor Roberts-Austen had been doing in connection with the rarer metals. The new use which had been pointed out for aluminium, in the reduction of other metal, was a factor of very great importance in the future of metallurgy. With regard to the manufacture of aluminium in this country, he was pleased to say that the British Aluminium Company were now about to place this industry in its proper position, as far as Great Britain was concerned. In the past, aluminium had been manufactured in this country by the chemical processes, but those processes had been altogether surpassed by the electrical process. The last he heard of chemical processes was when Mr. Vautin had produced, with very great industry and research, a sulphide of aluminium. He hoped for great things from that, but, up to the present, he had not heard that Mr. Vautin had been able to reduce that sulphide. The company he had mentioned would soon be able to manufacture aluminium in Great Britain in the same way as it was produced in Nordhausen, and probably better, because, having the bauxite mines in Ireland, and water-power in Scotland, they would have every natural facility for success. In fact, they would be giving a new industry to Scotland, and also to Ireland, in the manufacture of aluminium from bauxite. He was glad to hear that Professor Roberts-Austen had a new use for aluminium, and felt that this furnace had a great future before it. Everyone who had to do with chemistry knew that there was a very large future in the application of metals which, up to the present had hardly been used at all. They saw it in the incandescent gas lighting, and in alloys of various metals, and this last use would, probably, be of very great importance. They knew that one of the great drawbacks to the use of aluminium had been its want of tensile strength; but there was little doubt that the addition of a very small percentage of some of these rarer metals, which had hitherto been beyond practical use, would enormously increase its tensile strength.

Mr. PICKARD said he might reply to Mr. KITTO's question by saying that in all probability the reason they got an alloy of uranium and aluminium containing so much as 30 per cent. of the latter metal, was simply that they added too much aluminium for the purpose of reduction. It was not a simple matter to calculate exactly in the case of uranium, because they did not know the exact formula of its oxides, and they varied very much. The oxide of uranium, U₃O₈, they had not yet been able to analyse, but they had reason to believe it was very pure. Mr. Kitto had spoken very kindly of his part of the work, but he must say the whole merit of the discovery was due to Mr. Vautin.

The vote of thanks having been put and carried.

Professor ROBERTS-AUSTEN said he had not specially dealt with all the beautiful specimens on the table, but had only taken up two at random, the magnificent mass of manganese carbon-free, and the equally fine fragment of a larger mass of chromium which he handed to the Chairman as perhaps the most remarkable metallurgical specimen he had ever seen, both of which were produced by Mr. Vautin. On the table were also carbon-free tungsten, the only mass he had ever seen; uranium, and some molybdenum which Mr. Pickard produced at the Mint with him. There could be no question that a most important field was opening, and the cheapening of aluminium, to which Mr. Wallace referred, could not fail to play a most important part in metallurgy, by enabling them to get these rarer metals, and to add them to masses of their common associates, the effect of which was, in many cases, most remarkable. For instance, take the case of titanium, that would be most useful. When the Naval Architects met in that room very recently, reference was made to the difficulty in the use of aluminium for torpedo boats on account of the boats corroding on the line between wind and water. He knew an instance where a yacht was built for a French proprietor who was very well pleased with it until he moored it with an iron chain to an iron post, to which post was also moored a boat sheathed with copper. The result was that a gigantic battery was established, and the aluminium yacht was found to be dissolving away. The addition of 2 per cent. of titanium increased the durability of such a metal as aluminium when subject to the solvent action of salt water. It was impossible to say what might happen when they had studied the properties of alloys containing minute quantities of the rarer metals. He hardly dared mention their uses in connection with electricity; "platinoid" and "manganine" had already attracted attention, and it was impossible to say what valuable results might be obtained. Mr. Kitto's question had been answered by Mr. Pickard, of whose work, an old student of his own, he was naturally proud.

The proceedings then terminated.

HEMATITE MINING IN GREECE.—A new hematite mine at Marathion, in the village of Grammatico, Greece, was opened last year. The ore is carried down by a railway for about 5 miles to Limnionia Bay, where there is a jetty on the west side 200 feet in length, by means of which 1000 tons daily can easily be loaded. Proper appliances have been provided for mooring the vessels. The anchorage is considered quite safe, as it is well sheltered. The mine has been leased for 20 years by several French capitalists. The actual output is 6000 tons monthly, but if necessary the quantity can be increased to 15,000 tons. The ore is of an excellent quality, and contains 56 to 58 per cent. iron, 3·80 to 4 per cent. manganese, and 1·60 to 2 per cent. only of silica, but whenever the several lodes are found in contact with some small veins of yellow ochre the presence of a very slight percentage of arsenic is found by analysis, but this seldom happens.

The OURO PRETO GOLD MINES OF BRAZIL (LIMITED) has sold the gold obtained in the month of March, which realised £5224 9s. 4d.

MINING NOTES FROM JOHANNESBURG.

By H. BUSH, M.B.

(Cabled Weekly).

Knight's Mine.

One of the best samplers in Africa has sampled this mine for a local house, and his report is that the ore should give 15s. per ton profit. The third level gives pannings of over 1 ounce to the ton. Mine looking exceedingly well.

East Orion Mine.

This company owns 550 claims east of the Orion. Active work is now being carried on to locate the shoots of the payable ore. The company started with £50,000 cash working capital. There is a cyanide plant and battery on the ground. The reef being very flat the mine will be easily opened up and at a very low cost.

Meyer and Leeb (Black Reef).

It is estimated that there are only about 8,000 tons of payable ore left in this property.

South Orion.

415 claims on the dip of the Minerva. The reef will be struck at very narrow depths. Work not yet started.

Champ d'Or Deep Level and Teutonia

amalgamate on the following terms:—The new company is to have a capital of £550,000; £175,000 shares go to the Champ Deep shareholders, £100,000 to the Teutonia, £116,000 to the shareholders of the Ritsey Block of Deep Levels, which are also amalgamated.

Buffels Central Mine.

There is a tremendous dyke which will probably run through this property and smash up the reef, which will be hard to develop, owing to the surface soil being so heavy.

Buffels and Red Reef Syndicate.

This property is situated on the farm Eleazar to the northwest of the Eleazar Mynpacht, and is over 700 claims in extent. The capital of the company is £40,000. The prospects of the company are very good, and on the centre of the claims a quartzite formation is opened up, and gives very good assays from a formation over 20 feet in width. There are indications that this formation is the same as the Buffelsdoorn, and the owners are now putting down a borehole to test it at a depth.

Amazon Mine.

12 dwts. pannings, reef opened up for 500 feet averaging 2 feet in width. This mine will pay well with direct treatment.

Vesta Mine (Black Reef).

105 claims, reef 3 feet wide, payable prospects. Capital £50,000; company to be reconstructed.

Balmoral and Gardner Mines.

These mines are to be reconstructed, which will be advisable, as they are both payable propositions.

New Kleinfonteins.

Rich assays are being obtained from the lower levels, and the mine shows great improvement.

Orion Mine.

This mine is being worked much easier than it was in the past. The manager has traced shoots of gold throughout the property, and now this has been accomplished it can be expected that the returns will not only be maintained but increased during the next few months. The mine has opened up very well during the last few months, and the shoot of gold has been traced for a distance of 2,400 feet along the reef. This shoot of gold is about 300 feet wide, and averages 4 feet. Shoot No. 2 is about 100 feet in width, and is also traced through the property. There are also indications that shoot No. 3 will be found traversing the whole of the property. The new battery will start the end of July, and dividends of about 80 per cent. can be expected. Boring operations are being carried out to the south, and if a shoot of gold is discovered these shares will have a big rise.

United Main Reef.

An extra 20 stamps are to be erected. The main reef is now turning out payable. Mine looks very well.

Cassel Colliery.

Two seams of coal in sight; profit for the half year £15,893, after having written off £3,100. First month of last half-year output was 9000 tons; last month's output was over 18,000 tons. It is expected that the output will be 25,000 tons monthly, and the dividend will in time be 100 per cent. The quality of the coal is improving.

Drikoppies Diamonds.

Mine improving, and may give a good account of itself in a few months.

Robinson Diamonds.

Mine looks very well, and should pay dividends in the future.

Geldenhuys Estate.

There will be an increased output for the next few months. The residues assay 2 dwts., and this will be reduced to about 18 grains. Mine looks fair, reef averaging 5 feet in width. £100,000 in debt, which will be wiped off by increase of shares.

Reitfontein Mine.

Extensive development is now being carried on, and the mine looks better. It is expected that a profit of about £7000 a month will be made in a few months' time.

Crown Deep.

This will be a magnificent mine; the reef being large and rich it can be expected to be the most productive of all the Deep Levels. Mine is opening up splendidly.

Balkis Eersteling.

Financial position fair, reef proved to a depth, but has an uncertain value, and nothing great discovered so far.

Palmeitfontein.

(Portion of Henderson's Estates, Black Reef). As this farm may be floated it is well for investors to know that it is not proved to be another Orion, and I advise leaving it alone until the property is developed.

Elandslaagte Mine (Klerksdorp).

The work done by Mr. Joseph Pope on the property is a record for the grade of ore that has to be dealt with. The ore going to the mill only assays 6 dwts. 8 grains, and the working expenses are 14s. 10d., and with only 20 stamps a profit of £588 is obtained. This gentleman deserves every credit for bringing about this result, and it only goes to show that 6 to 7 dwts. ore will in the future be treated at a profit.

Buffelsdoorn Mine.

Although the prospects of this mine are very good, and it will be one of the big mine propositions in the Transvaal, yet the public have not had fair justice shown them in the gorgeous

plans that have appeared in the several papers which give one the idea that the reef is found through the whole line of country. The facts are these, that the outside of the Buffels Mine to the east the country is one huge mass of intrusive rock, and the reef is not seen (and will take some finding) through Reitfontein, Eleazar, or Reitkiel from the Buffels Mine on the west, and outside of the White Reef block the reef is of very little account.

Pocheftroom Estates.

Capital £450,000. The rumours about the Buffels Reef being found in the property wants digesting with a grain of salt, and the reef will be found in the country that can certainly be bought for far less than the present value of this property.

Champ d'Or Mine.

Owing to a collapse in the main shaft, there will be a slight difficulty in getting out the ore, so there may be a slight decrease in the output, but this is only temporary.

Jumpers Deep.

Active work being carried on. This will be a big mine in about 18 months' time.

Spes Bona.

Mine being developed, but nothing rich discovered.

Wolhuter Mine.

Mine opening splendidly; reefs will open out wider at the east and west boundaries.

Balmoral Mine.

If the present assays continue this will be a very rich mine.

Champ d'Or Deep Level.

There are Deep Level claims with ore worth about 12 dwts. to the ton, capitalised at from £10,000 to £15,000 per claim, and in this mine, after the dyke has passed through, the ore will go 15 dwts. to the ton. Under the present management this mine will likely prove to be one of the greatest gold-producers and dividend payers in Africa, and it is only in the matter of stamping power to put it in the first dozen mines.

Treasury Mine.

Twenty stamps will be running in about six weeks, and an extra twenty stamps are to be erected later on. Reef struck 6 feet wide in the vertical shaft giving payable results. Incline shaft reef being opened up, with ore of payable grade.

Molyneux Mines.

This property, which is situated on the outer edge of the basin and in the district of Heidelberg, comprises about 500 claims. The reef has been proved to a depth of 500 feet, the formation now being better defined and more regular. The reef is 1 foot wide, and gives assays of 2 ozs. to the ton. The company is to be re-constructed on the following terms:—Nominal capital £250,000; 50,000 shares are guaranteed at 30s. for working capital, and 30,000 shares under option at 30s.

Blinkpoort Mine.

Adjoining Molyneux Mines. Reef has been struck 1 foot in width at 100 feet in the borehole.

George Gochs.

Twenty extra stamps to be erected. Mine turning out a good one, and is a 20 stamp proposition.

Langlaagte Royals.

This mine is under a cloud, the South reef was worked to give the high returns some time back, and they have now to fall back upon the Main reef, which is of very low grade.

Steyn Estates.

This company owns a Deep Level block near the Durban Roodepoort. A borehole is to be started to strike the Main reef series at a depth of about 2000 feet. The mine on the Steyn reef is opening out very rich.

Croesus Mine.

The plant will be ready in about six weeks. Mine shows no improvement on the richest section (the eastern), and on the western the ore is very patchy, uncertain, and poor. The company at the present price with the present stamping power will return about 4 per cent., but for how many years it is uncertain.

City and Suburban Mines.

A dividend of 25 per cent. is to be declared this quarter, and it is estimated that dividends of 50 per cent. will be paid quarterly. Last month's profit was nearly £16,000, but this is above what will be the average in the future, but a monthly profit of about £13,000 can be relied upon, and dividends of 175 per cent. per annum declared. An extra 30 stamps are in course of erection, and when these are running there will be profits of £18,000 per month, making 250 per cent. The mine looks very good, and it has been found that there are patches on the western and central sections of Main reef that are payable; so in working out the tonnage of the ore in the mine and the ore that has been taken out of the mine, it has been found that the tonnage is greater than was expected, so here we have one great point in its favour of increased life. With the present stamping power, 130 stamps, it is estimated at 30 years.

Langlaagte United.

The mine is being well developed, and there are many months ore in sight, but the reef to the west is still of doubtful value.

Langlaagte Block B.

Under the new management everything is progressing favourably both in the mine and on the surface. It can be expected that this mine will be made a dividend-payer, but as the ore is of low grade nothing big can be expected.

THE PRODUCTION OF GOLD IN RUSSIA.—It appears from recent statistics that Russia holds the third place among gold-producing countries. The precious metal, however, is only found in large quantities in the Ural Mountains and East and West Siberia; and even there the production fluctuates considerably. During the decade 1880-1890, it was greatest in 1880, when the output reached 49,277 kilogrammes (equal to about 43 tons), gradually sinking to 33,020 kilogrammes (33 tons), and subsequently again rising to 39,405 kilogrammes in 1890, or upwards of 39 tons. The output in the Ural Mountains and in West Siberia appears to be steadily increasing, while there is a falling-off in Eastern Siberia, with the exception of the Amur district. According to the official returns for 1890—which are always several years behindhand—the production was, for West and East Siberia, 28,865 kilogrammes; Ural, 10,524½ kilogrammes; Finland, 17½ kilogrammes. This was the outcome of 23,000,000 tons of gold-bearing sand and ore. In the period from 1834 to 1892 East Siberia alone has yielded more than 1000 tons of gold. The expense of working varies so considerably that deposits which are regarded as well worth working in the Ural district are left entirely unworked in the Amur district. In the latter locality labour, food, machinery, transport, &c., are very expensive. The Russian Government is endeavouring to train up a staff of mining engineers, who will be expected to visit North America, South Africa, Australasia, and other gold-bearing fields.

THE BANK OF AFRICA (LTD).—The Bank of Africa (LTD) has opened a branch at Bulawayo, Matabeleland.

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APPENDIX 1 TO THIRD REPORT TO THE ALLOYS RESEARCH COMMITTEE.

THE ELIMINATION OF IMPURITIES DURING THE PROCESS OF MAKING BEST SELECTED COPPER.

By ALLAN GIBB, A.R.S.M.

IN the Welsh method of smelting copper the earlier operations concentrate the copper into a compact matte or regulus, known in smelting works as white metal, which in composition approximates to copper disulphide, Cu_2S . For the manufacture of ordinary commercial copper, the white metal is roasted completely to produce blister copper, by exposing it whilst melting, and after it is molten, to the action of a strongly oxidising atmosphere in a reverberatory furnace. This roasting process, however, may be stopped when any fractional part of the total copper in the white metal is reduced to the metallic state; and if the furnace charge is then tapped into moulds, some or all of these will be found to contain pigs consisting of two layers, the upper being a regulus of vesicular structure, known as spongy regulus, while the lower layer is metallic copper, known as bottoms. This partial reduction of the copper in white metal is the essential feature in the process of making best selected copper.

A modification of this process has also been followed, in which the furnace charge consisted not of white metal only, but of a mixture of oxides and sulphides of copper with coal. By the reducing action of the coal, varying quantities of metallic copper were separated and obtained as above, as copper bottoms covered with a layer of regulus.

Both of these methods are described by Dr. Percy in his account of the early practice followed for the manufacture of best selected copper, taken from a manuscript dating from about 1743. According to Le Play both were still practised in 1848; but the last method seems to have fallen into disuse in more recent times. For the production of best selected copper, which is the highest quality of copper that can be obtained by the Welsh process, the partial reduction of white metal, with the formation of spongy regulus and copper bottoms, has been extensively practised by copper smelters, for the reason that the spongy regulus was found to yield a purer copper than was obtained when the white metal was completely roasted to produce blister copper.

Impurities.

The foreign metals which occur in copper ores, and which have the most deleterious effects on the properties of the metals when it is used for making alloys that have to be rolled into sheets or drawn into tubes, &c.—such as the alloys of the copper-zinc series—are tin, antimony, bismuth, and arsenic. During the operations of smelting, all these metals to a greater or less extent pass into the white metal; and when it is roasted completely, so that the whole of its copper is reduced, they are found in large proportions in the copper so obtained. When, however, the white metal is treated by the process of partial reduction already mentioned, these metals concentrate in the copper bottoms, and the spongy regulus is proportionately freed from them. The whole amounts present of these metals do not pass into the bottoms; for, although their sulphides are all decomposed with more or less completeness by fusion with metallic copper, yet they all form double sulphides with copper disulphide; and it has not been found possible to decompose thoroughly these double compounds in the presence of excess of this disulphide, even when fused with a large quantity of metallic copper. Hence although on the large scale the proportion of copper reduced is large compared with the amounts present of these metals, their separation from the accompanying regulus is but fractional. In this research an attempt has been made to determine with some exactness the relative degrees to which these metals are separated from the regulus and concentrated in the bottoms. To that end, samples were taken from the products of the following operations on the large scale, and also of comparatively small experimental fusions in the laboratory:—

Actual smelting operations in reverberatory furnaces.

Fusions in crucibles in the laboratory.

The reason why samples were taken from blast-furnace operations was that the conditions which prevail in them are analogous to those of the process in which carbon was formerly used as the reducing agent. In the reverberatory furnace samples, the proportions of copper reduced and separated as bottoms were 8·2 and 16·0 per cent. of the total copper in the charge, while those from the blast-furnace formed 47·5 and 54·5 per cent. In order to fill up the wide gap existing between the percentages of bottoms from the reverberatory furnace and those from the blast-furnace, it was necessary to make experimental fusions in crucibles, in which other and intermediate proportions of copper could be separated. A fairly complete series was thus obtained, and the samples were all carefully analysed.

When white metal is treated by the partial reduction process for the production of bottoms, the metals—tin, antimony, bismuth, and arsenic—are not all concentrated in the bottoms to the same degree, even under similar conditions. The behaviour of each will, therefore, be considered separately.

Tin.

The concentration of foreign metals in copper bottoms is most marked in the case of tin. As this metal was absent from all the samples taken from actual smelting operations, as well as from those produced in the laboratory from furnace materials, tin sulphide was added to a regulus made by fusing electrolytic copper with sulphur; and the mixed sulphides were fused with oxide of copper. The fusion produced 107 grammes regulus and 22·7 grammes bottoms. The regulus contained 80·02 per cent. copper and 0·03 per cent. tin; the bottoms contained 97·62 per cent. copper and 2·01 per tin. Thus 20·6 per cent. of the total copper was reduced, and it contained 93·4 per cent., and the accompanying regulus only 6·6 per cent. of the total tin present in the original mixture.

Antimony.

Antimony is next to tin in the completeness of its concentration in the bottoms. When 8·2 per cent. of the total copper was reduced, 21·0 per cent. of the total antimony was found with it in the bottoms. This proportion rises to 80·8 per cent. of the total antimony, where 17·3 per cent. of the total copper is separated. From this point the proportion of antimony which concentrates in the bottoms does not increase much with an increase in the amount of copper separated, only reaching 93·7 per cent. of the total antimony when 47·5 per cent. of the total copper is separated as bottoms, and actually receding to 92·6 per cent. antimony with 54·5 per cent. copper.

Bismuth.

With a separation of 8·2 and 16·0 per cent. of the total copper as bottoms, 11·1 and 43·1 respectively of the total bismuth

passes into the copper bottoms. There is hardly any further increase in the concentration of the bismuth with any increased proportion of copper reduced. When 47·5 per cent. of the total copper is separated as bottoms, only 47·6 per cent. of the total bismuth is found in them.

Arsenic.

The proportions of the total arsenic which concentrate in bottoms are 21·5 and 30·6 and 60·2 per cent. respectively, when 8·2 and 16·0 and 25·2 per cent. of the total copper is separated in that form. Arsenic thus differs from bismuth in the rate of its elimination from the main bulk of the copper. With 8·2 per cent. of the copper as bottoms, a larger proportion of arsenic than of bismuth passes into them; while with 16 per cent. the proportion of bismuth concentrated in them is greater than that of arsenic. But at the latter point the concentration of the bismuth has practically reached its maximum; while in the case of arsenic this is only attained when 34·7 per cent. of the total copper is reduced.

In all the experiments considered thus far, the proportions of the contaminating metals are small, but are such as are found in the furnace materials commonly treated in British smelting works. The presence of large proportions of some metals often affects notably the concentration of others; a marked example is afforded by the behaviour of the metal nickel when it occurs along with arsenic.

Nickel, and Nickel with Arsenic.

When present alone, nickel does not appear to concentrate in bottoms. Only 8·0 per cent. of the total nickel is found in them when they contain 8·2 per cent. of the total copper. But when arsenic occurs together with nickel, and both are present in high proportions, they concentrate largely in the separated copper. Thus, with a separation of 19·3 per cent. of copper as bottoms, 77·7 per cent. of the total arsenic and 47·9 per cent. of the total nickel are found in them, and when 28·3 per cent. of copper is reduced 83·9 per cent. of the total arsenic is concentrated in it. This is not contrary to expectation, in view of the well-known practice of concentrating nickel in a *speise* (that is, a combination of arsenic or antimony with iron, copper, nickel, &c.). The materials in these experiments contained silver; and it is worthy of note that its concentration is lessened by the presence of arsenic and nickel.

The concentration of gold and silver in copper bottoms has also been determined, although this hardly comes within the scope of the title of this paper; for when these metals are present in proportions large enough to affect the mechanical properties of copper, their value is sufficiently great to necessitate other and special methods for their extraction. As, however, gold and silver were both present in the materials of the other experiments, it was thought a matter of interest to ascertain to what extent they could be separated from the regulus and concentrated in the bottoms of the "best selected" process. The concentration of gold in bottoms has been, and is, carried on as a means for its extraction from copper ores; but the concentration of silver is not sufficiently complete to render the process applicable for its separation.

Gold.

With a reduction of 8·2 per cent. of the total copper as bottoms, they contain 41·5 per cent. of the total gold; whilst when 14·4 per cent. of the copper is reduced to bottoms, the whole of the gold is found in them. In some cases traces of gold remained in the regulus; but they were too small to be weighed, even when 50 grammes of the samples were taken for assay.

Silver.

Silver nearly reaches its maximum concentration in bottoms when 19 per cent. of the total copper is separated in this form, 42·9 per cent. of the total silver being then contained in them.

Effect of Metallic Iron on the Concentration of Metals.

The addition of metallic iron during the separation of metals from a copper regulus and their concentration in bottoms was the subject of a special experiment. Metallic iron completely decomposes the sulphides of antimony, lead, and silver; but when these are present in the complex sulphides produced in lead smelting, their complete separation is not possible; and although iron reduces copper from the higher sulphides produced in the Welsh process of copper smelting, its action is gradually lessened with the increasing proportion of iron sulphide thereby formed. Copper sulphide, with which has been melted sulphonides of lead, antimony, silver, and gold, was remelted with an excess of iron. The proportion of total copper separated as bottoms was 35 per cent.; and in it were concentrated:—

74·5	per cent. of the total silver
83·5	" " " lead
97·0	" " " antimony
92·8	" " " gold

It will be seen that there is a notable increase in the proportions of antimony and silver concentrated in the bottoms, when compared with those in the experiments previously considered in which iron was not used.

Conclusions.

From the experimental results given above and in the tables the following conclusions may be drawn. Of the four metals—tin, antimony, arsenic, and bismuth—tin is concentrated in the bottoms in the highest degree, antimony approaches tin in this respect, arsenic is concentrated in smaller proportions, and bismuth scarcely at all. When about 20 per cent. of the total copper in "white metal" is separated as bottoms by partial reduction, the copper obtained by roasting the remaining spongy regulus will contain about 90 per cent. less tin and about 80 per cent. less antimony—and, when 25 per cent. of copper is separated, about 60 per cent. less arsenic—than the copper which would have been produced by roasting the white metal completely. In regard to bismuth, the copper produced from the spongy regulus, when 16 per cent. of the total copper has been separated as bottoms, will contain only about 43 per cent. less bismuth than the copper which would have been obtained by complete roasting. The purifying effect of the separation of bottoms in the removal of antimony from the spongy regulus is but little increased when a larger proportion of copper than 20 per cent. is thus separated; and in the removal of arsenic and bismuth the increase not only almost ceases when 25 per cent. and 16 per cent. respectively of copper are separated, but the purifying effect as regards arsenic is actually lessened when more than 35 per cent. of copper is separated as bottoms.

It is hence clearly evident that in the process for making "best selected" copper the proportion of copper separated as bottoms should not exceed 20 per cent. of the total copper in the furnace charge, a larger proportion having the effect not only of diminishing the yield of "best selected" copper from the spongy regulus, but also of impairing its purity.

The directors of NIGEL EXTENSION (LIMITED) have declared a bonus dividend of 10 per cent. (1s. per share) payable on June 12.

PROVINCIAL SHARE MARKETS.

THE CORNISH MINE SHARE MARKET.

MRS. SAMUEL JOHN DAVEY, Dealer in Cornish Mine Shares, Redruth, Cornwall, reports under date of May 16 (four o'clock) as follows:—We have had an excited market this week, with rapidly fluctuating prices, but not many transactions. Dolcoath shares jumped £10, Carn Brea £1, Tincroft £2, Wheal Bassett £1½, and Wheal Grenville £2, but to-day prices are lower, and market is flat. Following are quotations:—Blue Hills, ½ to 2; Carn Brea, 2½ to 2½; Dolcoath, 47 to 49; East Pool, 5½ to 6; Killifreth, 7s. to 9s.; South Crofty, ¾ to 1; South Wheal Frances, ¾ to 1; Tincroft, 7½ to 7½; West Frances, ¾ to 1; West Kitty, 6 to 6½; Wheal Bassett, 1½ to 2; Wheal Grenville, 12 to 12½; Wheal Kitty (St. Agnes), ½ to 1; Polberro, 1 to 1½.

Mr. MICHAEL WILLIAMS BAWDEN, Mining and Assaying Office, Liskeard, Cornwall, writes (May 16) as follows:—The mining market has been active, and all shares have considerably improved with firm holders; but to-day prices are easier, and more shares offering on the tin standard again receding. At Phoenix United Mines meeting, held at Webb's Hotel, Liskeard, to-day, the accounts, as presented by the liquidators, showed a profit of £82 4s. 4d. on the three months' working. It was resolved to continue operations for another three months:—Blue Hills, 9s. to 10s.; Carn Brea, 2½ to 2½; Cook's Kitchen, ¾ to 1; Devon Consols, 37s. to 38s.; Dolcoath, 50 to 50½; Drakewalls, 2s. 9d. to 3s.; East Pool, 5½ to 5½; Killifreth, 11s. to 12s.; Levant, 6½ to 6½; Polberro, 19s. to 20s.; South Crofty, 1 to 1½; South Frances, 1 to 1½; Tincroft, 7½ to 7½; West Frances, 1½ to 1½; West Kitty, 6½ to 6½; Wheal Bassett, 2½ to 2½; Wheal Friendly, ½ to 1; Wheal Grenville, 12½ to 12½; Wheal Kitty, 4s. to 5s.

Messrs. ABBOTT AND WICKETT, Stock and Share Brokers and Mining Share Dealers, Redruth, write under date of Thursday, May 16:—In the early part of the week most shares had a considerable rise, but yesterday and to-day prices have receded in sympathy with tin. The disposition to buy has been checked. Dolcoath, which touched 54, have fallen to 48. Quotations herewith:—Blue Hills, ¾ to 1; Carn Brea, 2 to 2½; Dolcoath, 47 to 49; East Pool, 6 to 6½; Killifreth, ¾ to 1; Polberro, 1 to 1½; South Crofty, ¾ to 1; South Frances, ¾ to 1; Tincroft, 7½ to 8; West Frances, 1 to 1½; West Kitty, 6 to 6½; Wheal Bassett, 1½ to 2; Wheal Grenville, 12 to 12½; Wheal Kitty, ½ to 1. Tin, 66s.

MANCHESTER.

Messrs. JOSEPH R. and W. P. BAINES, Stock and Share Brokers, Queen's Chambers, 7, Market-street, write May 16 (noon):—The markets this week have shown some abnormal changes, but there having been fluctuations (in many cases wide), the balance of change for the week is very irregular, and the extent of the actual alterations as compared with Thursday last are not particularly large in amount, except in a very few cases. Home rail, after a rapid and generally good rise, have slipped away again, but they mostly retain advances the exceptions where declines on the week are to be noted being few and small. In the American market figures have moved up and down sharply and widely; here too the balance of alteration on the week is very evenly held, advances and declines being about the same, but in amount the advances have a little the best of the figures. In Canadians Trunk issues are all lower from ½ to 1½, but Pacifics are 82½ higher. Mexican Rail easier. Consols have fallen ½, and New Zealand Inscribed, with a fall of ½, is the only change in colonials. Home corporation stocks better where changed—viz., Oldham Four per Cent. 2, Birmingham Three per Cent. ½, and Manchester Three per Cent. ¼ higher. The market for foreigners has a good record of varied quotations, with a large majority of advances. Indeed, the declines are few and small, so much so as to be hardly worth naming save for their exceptional position. Higher: Brazilian Four and a-Half per Cent. 2½, Argentine Five per Cent. 1½ to 2½, ditto Six per Cent. 1½, Russian Four per Cent. ½, Uruguay Three and a-Half per Cent. ¾ to 1, Egyptian United ¾, Portuguese Three per Cent. ¼, and Turkish D. ½. Lower: Spanish Four per Cent. ½, and Italian Rentas ½. Turning now to the daily details in rails we recite them as follows:—Friday last found things firm to strong all round. Home rails stood well, South-Eastern A being well to the front with rise of nearly 2. Mexican Rail issues were higher to extent ranging from 1 to 2½. Canadians generally, whilst harder, were not greatly altered in quotations. Americans responded from the first to better New York prices, and held up to close, which was still firm. Saturday produced an unlooked number of transactions for a Saturday, Americans getting the largest share of the dealings. Prices herein were good from start to finish. Home rails also good, better prices being very general. Grand Trunk issues and Mexican Rail also improved. Rio Tintos came into request. On Monday a change came over the tone of things, some trouble (which was exaggerated) in the mining market bringing on the change. Home rails were contradictory, but declines were ahead of advances. Though Americans opened buoyant, this feeling soon gave way on selling pressure, and the falling-away continued down to close, when figures showed early advances wiped out, and declines against Saturday's finish. Mexicans and Canadians had a similar record to the last-named. On Tuesday the market opened in a very flat condition, but about mid-day the tone changed again, and the improvement continuing down to the finish, some advances actually on the day were marked, particularly in Americans. Home rails were easier as a whole, as also were Grand Trunks. Yesterday dull all round with lower prices all but without exception where any change is made at all. Americans began badly, and ended worse. This morning prices open but poor again. Home rails not much altered from last night, but Americans lower in response to some distinctly depreciated prices from the other side. Miscellaneous business has not been so brisk, notably less has been going on in unlisted mining shares, and the listed and unlisted alike have (although in some cases rallies have occurred) shown large shrinkage of value on the week. These remarks apply generally, though, as a matter of fact, in those quoted here advances are in majority, after relapse from advances. The principal decline in the last-named is in Chartered, which quote 13·16 down, and have fluctuated widely. Coppers at one time were brisk and better, but have lost a lot of their advance. BANKS are better in several cases, whilst declines are few and small.

INSURANCE neglected, and quotations altered irregularly. COAL, IRON, &c.—Fair business done in Ebbw Vale and Blaenavon, and what few changes there are in prices are, whilst small in amount, all on the side favourable to holders.

MINES we have already spoken of.

COTTON SPINNING, &c., SHARES.—Lull in business, but figures are fairly well maintained.

TELEGRAPH AND TELEPHONES.—Anglo, Ordinary and Preferred, 2 and 1½ respectively, Telegraph Construction 1, and National Telephone 3·16 higher. Lower: Eastern Extension ½.

BREWERY.—Higher: Allsopp's 4½, Yates Debenture 1, and Threlfall's Preferred 4. Lower: Chester's Ordinary ½, and Clarkson's 1.

MISCELLANEOUS.—Higher: Brunner, Mond ¾ to 1, Hudson's Bay ½ to ½, United Alkali 5·16, Gas Light and Coke A 3, and a few others fractionally. Ship Canal issues have dwindled all week for both issues.

LATER (4 P.M.).—Home rails again a little easier to-day. Both Canadians and Americans opened very flat, and this tone obtained till turned noon. Then they came into better odour and rallied sharply, the last half-hour showing the best in the rally. Mexicans, too, have strengthened a little. Ship Canals have this afternoon rallied a little from the worst, more especially the Ordinary.

SCOTCH MINING AND INDUSTRIAL COMPANIES
SHARE MARKETS.

STIRLING.—Mr. J. GRANT MACLEAN, Stockbroker and Ironbroker (May 16) writes:—During the past week there has been less business doing. Prices have in many cases declined on realisations and liquidations. There is little prospect of a recovery before the next settlement, although there is nothing discouraging in the state of the different properties.

In shares of coal, iron, and steel companies prices are steady. African coal are at 9s. 6d., Addie and Sons Preferred 9s., Marbella 53s., Niddrie 43s., Steel Company of Scotland 50s. 6d., Shott's Iron 19.

In shares of copper concerns a considerable amount of business has been done. In sympathy with the advance in the copper market. Tharsis rose to 107s. 6d., Arizona 35s., and Tinto 17s., but they have since given way to 101s. 6d., 25s., and 15s. ex dividend, respectively. Central Chili are at 2s. 6d., Mason 60s. The revival in the metal markets has increased dealings in home mines. Great Laxey are at 33s. 6d., Dolcoath 53s., East Pool 6s., and Killifroth 11s. to 13.

In shares of gold and silver mines a large business continues to be done. The shares that have been thrown down by the liquidation sales have principally been Chartered to 70s., East Rand to 90s., Johannesburg Investment 80s., and Roodepoort Deep to 65s. Consolidated Gold Fields Ordinary declined from 10s. cum dividend to 8s. 15-16 ex dividend. There has not been much doing in Indian mines. Mysore Gold Fields are at 27s. 6d.; it is stated they completed sale of a portion of their property at a good price, and that the first crushing would be announced at the end of the month. Broken Hill improved from 40s. 6d. to 47s., and are now 45s. 6d.; Africander are 50s.; African Land, 9s.; African Estate, 47s. 6d. to 50s.; African Recovery, 30s. 6d.; Bendigo, 8s. 3d.; Balkis Kersteling, 5s.; Big Golden Quarry, 3s. 6d.; Block B, 25s. 6d.; Bayley's Reward, 8s. 6d.; Bechuanaland, 4s.; Charters Towers, 4s. 3d.; Caratal, 1s. 6d.; Caledonian, 4s.; Carrington, 9s. 6d.; Day Dawn Block, 11s. 6d.; Dickens Custer, 2s. 3d.; East Sheba Reef, 3s.; Empress of Coolgardie, 14s. 6d.; Graskop, 6s. 6d.; Golconda, 23s. 9d.; Guy Fawkes, 13s.; Glencairn, 80s.; Gordon Diamond, 8s. 9d.; George and May, 32s. 6d.; Hampton Plains Exploration, 8s.; Idaho, 5s. 6d.; Jumper, 5s.; Klerksdorp, 23s.; La Reine d'Or, 18s.; Luipaard's Vlei, 21s.; Lower Roodepoort, 6s. 6d.; La Plata, 3s.; Londonderry, 14s.; Montana, 12s. 6d.; Murchison Gold Fields, 7s. 9d.; Mozambique, 30s.; Moodie's, 28s.; Mallina, 16s. 3d.; North Sheba, 8s. 6d.; New Queen, 8s. 6d.; New Rand, 18s.; Nine Reefs, 3s. 9d.; Otto's Kopje, 6s. 9d.; Paarl Central, 29s. 3d.; Rhodesia, 9s.; Royal Oak, 1s. prem.; St. Augustine, 14s. 6d.; Sheba, 35s.; South Luipaard's Vlei, 3s. 3d.; Sutherland Reef, 13s.; Sheba Queen, 5s. 6d.; Tati Concessions, 67r.; Thistle Reef, 5s. 6d.; Violet, 31s.; Victoria and Altimira Pref., 2s. 10d.; Wemmer, 11s.; Westleigh, 17s.; Wolverand Klerksdorp, 16s. 3d.; and Willoughby, 26s. 3d.

In shares of miscellaneous companies, prices are steady.

In oil companies shares there is not much alteration. Although the price of burning oil has been reduced 1d. per gallon, the price of sulphate of ammonia has advanced. Broxburn are 12s. 9-16, Pumpherston 9s., and Young's 43s.

EDINBURGH.

Messrs. THOMAS MILLER AND SONS, Stock and Share Brokers, 69, Hanover-street, Edinburgh, report as follows under date of May 16:—A large business has been done during the past week, in which the more speculative railway stocks have had a prominent place. Prices have latterly suffered reaction in most departments. The following are some of the changes:—Caledonian Railway Deferred has improved from 45s. to 45s., Glasgow and South Western from 108s. to 110s., Brighton Deferred from 158 to 159s., North British has declined from 39s. to 39s., Chatham from 19s. to 19s. British Linen Bank has improved from 38s. to 38s., Royal from 217 to 222, Commercial have receded from 69s. to 68s. In insurance shares, North British and Mercantile have improved from 39s. to 40, Commercial Union from 35s. to 35s., Scottish Life from 37s. to 38s., Caledonian have declined from 27s. to 27s., Australasian Mortgage and Agency Preference stock has improved from 65 to 70, Edinburgh Investment Trust Deferred from 46 to 48, London Scottish American Trust Deferred from 45 to 50. British South Africa shares have receded from 92s. 9d. to 73s. Arizona Copper, after rising from 29s. to 35s., have fallen again to 25s. 3d. Rio Tinto, after advancing from 16s. 13-16 to 17s., have fallen to 15s. 16. In oils, Broxburn have receded from 12s. 9-16 to 12s. Pumpherston from 9s. to 9s. Young's from 47s. 3d. to 43s. 6d. Linlithgow have improved from 37s. 6d. to 41s. 6d. Distillers 1s. 3d. lower at 17s. 5-16. Coats 15s. higher at 24s. The general market had a firm tone at the close.

NOTES FROM ANDALUCIA.

PROCESS OF CALCINATION WITH MANGANESE
AND SALT OF CUPROUS PYRITES.

By W. GUTHRIE BOWIE.

THIS in the laboratory shows advantages, but chemists will easily understand what effect these can have on heaps of this pyrites calcined so slowly in the open air. Companies have tested this process and found the expenses would be great and the benefits nil, while calcination is necessary. The price at which the poor in manganese ores were bought ranged from 4 to 5 reales per cwt. of 50 kilos put in Gibraleon or Huelva; that paid by one company was more than can be obtained for first-class ore put in England, while much rubbish was passed, a matter the chiefs at the mine could not remedy, however adverse to the process, nor could they make cheaper or better contracts with those who made offers, as this was a monopoly over which they had not the slightest control.

Replying to enquiries as to its use in a mine under my management, I stated that it was impossible to be guided by the results at Rio Tinto, as there were no statistics of previous production to prove its utility over such large expenses; but seeing the process was a patent of one of the directors, and some of them had the monopoly of supplying the materials, no doubt as such, they were satisfied as to its advantages to the company, but that no other mine in the Province had adopted it, not even Tharsis.—Third mortgage: This was somewhat of a surprise, as the company had already paid its floating debt, as well as a good dividend, while the reports went to indicate that 11,000,000 tons of ore had been laid open, and that only by a few inexpensive appliances, greater extraction could be obtained, even to the snuffing-out of half of the copper mines of the world, and stop others from starting; a profit of £1,200,000 being estimated by "Glamorgan," in a letter to *The Mining Journal* for 1888, expressing the hope that all the 5 per cent. debentures would be replaced eventually by others 3s. or 4 per cent., and leave a profit of 23 per cent. with copper at £40 per ton. Has this been done shareholders enquire. A large reservoir was commenced in construction, but, after considerable expenses, again abandoned, and thus lost. This and the coal schemes, also failures, are all to show the necessity or use of this third mortgage.

Rio Tinto, in common with some other mines, has suffered from a kind of chronic disease of plunder by alcaldes, judges, lawyers, merchants, contractors, &c., which the chiefs have never been fully able to root out, while the company has been much mixed in Spanish politics, hence many expensive and unnecessary employees and abuses that are now being rectified as far as possible.

MINING IN CORNWALL
AND DEVON:
NOTES ON MINING IN THE WEST.

(BY OUR SPECIAL CORRESPONDENT).

DURING the last week, and particularly on Monday and Tuesday of this week, there was more excitement on the Redruth Mining Exchange than has been experienced for a very long time. The rapid rise in tin had an immediate effect on shares, and the few who had been offering shares at the low prices quickly drew in their horns. The firm tin market brought a heavy demand for shares which, in the absence of any offerings it was impossible to meet. The demand has continued up to the time of writing, and although a large number have changed hands at the higher quotations, the orders in a great many cases remain unexecuted. The shares which have principally felt the rise have been Dolcoaths, which advanced from £12 to £15 on the official announcement of the scheme; Wheal Grenvilles, Tincroft, West Frances, South Crofty, Wheal Bassett, and Carn Bras. Many of the low-priced shares doubled and trebled in value, a striking confirmation of what we have repeatedly contended, that, with a rise in tin, the advance would be so marked, that only the holders would be fortunate enough to secure the full benefit of it. Even with the reaction in tin on Wednesday the prices of shares remained firm.

THE chief topic of interest continues to be the conversion of Dolcoath into a Limited Liability company, and general gratification is expressed at the successful termination of the negotiations with the lord, and the practical unanimity with which the shareholders have endorsed the recommendations of the committee. The scheme does not, of course, command absolutely universal approval; it was inevitable that those who had bought their shares at high prices should raise a belated protest, but opposition from that quarter was discounted beforehand, and was of anything but a formidable description. Mr. Henry Rogers, by his wild flights of arithmetical fancy, lent a tinge of burlesque to the discussion, and the fallacies on which his extravagant figures were based were happily ridiculed by Mr. Lanyon. There is a general feeling of relief, both among the shareholders and outside, at the termination of the period of suspense, and other bodies of adventurers who are contemplating a similar transformation will be encouraged to persevere. It is evident that the conversion of Dolcoath marks the beginning of the end of the old Cornish Cost-book system. Vast profits have been realised under it but the times have obviously outgrown it, and it has become a mere anachronism, an antiquated and discredited survival. Readers of *The Mining Journal* will be aware that such a movement as is now being initiated in Cornwall has long been advocated in these columns as affording the best solution of the difficulties under which it has more than once seemed too probable that Cornish mining would succumb.

We regret to hear that Captain Josiah Thomas, who, under our new scheme, will occupy the position of managing director of Dolcoath, is still very unwell. He starts this week in one of the South African boats, in company with his son, Dr. Telfer Thomas, on a cruise, which, it is hoped, will go a long way towards restoring him to his usual robust health.

THE Wheal Agar water difficulty remained unsettled at the time of writing, and had, in fact, reached a more acute stage. On Wednesday morning the East Pool miners declined to go underground, and, making up their minds for a demonstration, marched to Tincroft, with the object of securing the co-operation of the men employed in that and other mines likely to be affected by the cessation of pumping operations at Agar. At the other mines, however, the men had gone underground, and East Pool miners contented themselves with a visit to Mr. Croddard, the agent of Mr. Bassett, the lord of both Carn Bras and East Pool. They asked him to use his influence to bring about a renewal of the pumping at Wheal Agar. There is no danger at East Pool of such an inrush of water as would jeopardise the lives of those employed underground, but the men are evidently anxious that some arrangement should be arrived at before the water rises over their workings, so as to deprive them of employment. We hope that by the time this note appears in type some arrangement will have been made of the restarting of Wheal Agar engine. The cost of working it is so trifling compared with the risks the adjoining mines run, that the difficulty ought never to have arisen.

THERE has been yet another meeting of the shareholders in West Seton, and the position was even worse than that which had to be faced some years ago. Extremely little has been collected from the defaulting shareholders, some of whom are abroad. A special committee has now been appointed for the express purpose of bringing pressure to bear on those who still owe calls, but in all probability a small further call will be necessary to clear the books. If all unpaid calls had been good there would have been a balance in hand from which to have paid a dividend.

"HOW TO GET GOLD.—THE PROBLEM SOLVED."—This is the title of a 46 page pamphlet by "Dr. Astroscopist," and published by John Bale and Sons, Oxford House, Oxford-street W. The object of the book is twofold—firstly to give in untechnical language a kind of text-book of metallurgy, with the object of showing the great difficulties that exist of successfully extracting gold; secondly, to show that the problem has been solved by the invention of a new furnace by Mr. Charles J. Faustel. This furnace is well known amongst mining engineers, and certainly it has met with a great deal of success where other processes have failed. The inventor's method is to decompose the refractory elements in the ore by the process of Nature—heat, air, and water—and to recover the gold by amalgamation with mercury. He claims that the process is more simple, quicker, more efficient, and more economical than other processes, and that it will actually deal with pyritic ores, where the oxidation of the refractory elements is essential to amalgamation. No one would be more delighted than ourselves were this to prove as successful as the author anticipates, for it will be a step nearer to the problem which we are all anxious to solve as soon as possible. We are content to await results.

A special general meeting of shareholders in the GELDENHUIS ESTATE AND GOLD MINING COMPANY (LIMITED) will be held at Johannesburg, South African Republic, on Tuesday, the 25th of June, for the purpose of considering a provisional agreement with the Treasury Gold Mining Company (Limited), whereby that company will receive six claims in the mynpacht of the Geldenhuis Estate and Gold Mining Company (Limited), and 3/4 claims outside the mynpacht, with certain plant, as well as lease of a small strip of mynpacht for the purpose of surface working, in exchange for 35,000 shares, fully paid up, of the Treasury Gold Mining Company (Limited). The transfer registers will be closed from 20th to 26th instant, both days inclusive.

REPORTS FROM THE MINES.

COLONIAL, INDIAN, AND FOREIGN.

CHIAPAS.—Mine report for fortnight ending April 15: Providencia Aver driven 9 feet, total 247 feet. Following streak carrying pyrite. Taylor main extension driven 7 feet, total 622 feet. Rock somewhat softer. Santa Fe Hill No. 3 drift driven 6 feet, total 59 feet. No change. Taylor Copper Creek driven 16 feet, total 196 feet. Continued a few feet further in order to cut across under the creek. Sylvia crosscut No. 2 driven 4 feet, total 102 feet. No change, still in white wollastonite. Sylvia crosscut No. 3 driven 6 feet, total 25 feet. Showing a few colours of ore. Pine Creek No. 2 driven 15 feet, total 49 feet. Still in dyke rock. Pine Creek No. 3 driven 10 feet, total 46 feet. No change. Providencia Aver rise No. 1 driven 7 feet, total 30 feet. About 2 feet of ore in the back.—Extraction. Old Providencia 347 tons. In general appearance improved. Santa Fe Hill 40 tons. Still following a little ore. Santa Fe stops 300 tons. Generally improved in appearance. Taylor No. 3 17 tons. In good ore, but smaller. Providenciarise No. 1 29 tons. Poorish ore. (Signed) Edward T. McCarthy.

NO. 7 NORTH EAST QUEEN.—The following report has been received from the mine, dated Charters Towers, March 29: Tuckett and party above No. 1 level east are working on about 4 inches of mineral stone, which prospects very well. They put up a rise about 15 feet, and then beat back towards the shaft, they are now holed through, so that they have now one open end to start stowing from, and should be able to break stone faster. They have about 2 tons broken below.—Mills and party. In their drive going east they have an average of 10 inches of good stone. This drive shows a better defined reef now than it has done, the stone making into a more solid reef in the face. Their stope on the western side does not look so well as last reported on, most of the stone being pinched out. They have now an average of 4 inches for about 10 feet along the stope.—Backs and party. This party below No. 2 level on the western side of the shaft have an average of about 8 inches of stone, for a distance of 20 feet or more along the face. They have put in a drive from the winze into the shaft about 40 feet below plat, and will be able to get out their stone much faster now. They have 6 or 7 tons broken below.—Balch and party. As I predicted in my last report, the reef is much more defined here than it has been hitherto, averaging over 10 inches in the face at present, with a nice dig over the reef in the lower side, assisting materially in their progress. Wherry and Williams, over the intermediate level between Nos. 3 and 4 east have 50 tons of stone broken below. The hanging-wall is much broken up with them, and, therefore, takes a deal of their time with timber. They have about 1 foot of stone of poor quality on the footwall, which they only save the best of, and from 2 inches to 6 inches of good on the hanging wall of good quality. I have let a block below them, from a pass back towards No. 3 pass in No. 4 level, to Tyzer and Cherry; also the adjoining ones to Wherry and party, to Paull and Williams. Both these parties intend to start in May. We have hauled for the fortnight 13 tons of quartz. Several men have been off with the Dengue fever so that our output for the fortnight is smaller than it would have been otherwise.—(Signed) John T. L. Williams.

OUBRO PRETO.—Passagem Mine report for March: Incline shaft No. 1 was sunk 240 metres in quartzite, with quartz lode standing over roof. 505 end north east was driven 320 metres. It shows a small branch of ore, but is mostly in schist. 505 end south west was driven 420 metres. The ore has dipped under the floor of the level, and the heading is at present in schist. 470 end north east was driven 320 metres, part of the distance full size in good quality ore, but latterly in horse of poor schist; it is expected though that this will cut out again shortly. 470 end south west was driven 180 metres in mixed schist and quartzite without ore. 435 end north east was driven 360 metres. The lode has made a sharp bend, and the end is at present in quartzite, with ore under floor. Crosscut at 435 between shafts was driven 0.90 metres. It is getting into the footwall, and lower half of level is in schist. Driving will now be pushed on to hole to winze from 400 to allow of stopes being opened along the bottom of that level. 400 end north east was driven 440 metres. It carries a branch of lode 0.50 metre thick against the roof, the rest of the end being in quartzite. Winze under 400 north east was sunk 3.90 metres. It has gone down in strong massive lode until within the last metre, when it got into footwall schist. The total thickness of quartz passed through in this winze is over 8 metres. 365 end north east was driven 320 metres. Against the roof there is a bar of very hard quartzite, about 1 metre thick, but below this there is strong lode, which holds under floor of level. The lode has made a bend exactly similar to that at the 315 level when entering the Buraco Secoo shoot, and from the direction and inclination of that shoot it would appear that we have now intersected it at the 365 level. Rise between crosscuts at 365 north east was advanced 3.10 metres, but is at present in a bar of poor quartzite. Rise over 315 north east was advanced 2 metres in mixed schist and quartzite, without change, 215 end north east was driven 5 metres, and is again nearly full size in ore, the lode carrying one or two small lines of quartzite. Rise from stope under 215 north east was put up 5.60 metres, and holed to the level in a branch of ore about 1 metre thick.—Stoping. The stope at the 435 level shows no change. The lode is of a strong massive appearance, carrying scarcely any sterile rock, and averaging throughout the four stoves worked over 4 metres thickness, and in the stope nearest No. 2 shaft it is over 5 metres thick. At the 400 level between shafts, the upper stope which has no cross under the 365 level continues to produce a good amount of ore, the lode being 3.50 metres thick, and composed mostly of quartz of fair average yield. Below this a stope is being worked on a lower line, and shows a branch of good pyritic ore, 1 metre thick, in footwall schist. A pillar of lode against the level is also being stoned, and shows about 3 metres thickness of good milling ore. In the stope south west at rise 28 the lode continues of great size, and though it carries at this point a good deal of schist and quartzite, there is still nearly 3 metres thickness of quartz, which shows good patches and strings of pyrites throughout. North-east of No. 2 shaft at this level the lode in the inner stope has become pinched, and is now about 1.30 metres thick, but the outer stope is in a swell of the lode and the ore assumes the shape of a big chimney, similar to that worked on the same run at the 315 level. At the 366 south-west the stope shows no change, the lode holding up regularly about 3 metres thick, and carrying a fair amount of pyrites. In the inner stope the lode carried a large amount of schist, and only about half the stuff broken is milling ore. The stope at the 315 south-west close to rise 30 presents the same appearance, and for the present are not very productive, though from what is seen in the rise the lode will open higher up. The inner stope at this level is looking well, the lode continuing to increase in size, and is now over 4 metres thick, with a fair amount of pyrites. Two other stopes are worked over this level, but the ore is very much mixed with quartzite, and a large amount of sterile rock has to be broken. At the 315 north-east the stope below the level show little change, and continue in regular lode 3 metres thick. They are now very near the level and the ground between will soon be worked out. The stope in the Buraco Secoo shoot at this level continues to look well. From the excavation under floor of level a stoning face 4 metres high was carried forward in solid mineral, and a good quantity of high grade ore has been produced. Under the 215 south-west a large amount of filling and building has had to be done to secure the roof and prevent a run of ground, but a fair amount of pyritic ore is at the same time produced by taking down a branch of ore which was left standing against the roof. At the 215 north-east the stope shows no change, the lode carrying a bar of schist with quartz against roof and floor, each branch being about 1.50 metres thick.—(Signed) Henry J. Gifford.